No. XX.

An Account of an Improvement made on the Differential Thermometer of Mr. Leslie. By Elisha De Butts, M. D. Communicated by Dr. B. S. Barton, one of the Vice Presidents of the Society.—Read, June, 1814.

THE results to which the European philosophers were directed by their investigations upon the nature and propagation of heat, have been sufficiently important to attract the attention of every person engaged in the pursuit of natural science. The mystery which involved the connexion that existed between heat and light, has been to a certain degree removed by the observations and experiments of Lambert, De Saussure, Scheelc, Pictct, and Herschell, which have shewn that the rays of heat can be separated from those of light by refraction, and by plane diaphanous bodies. When a sun-beam was compelled to pass through a prism, the rays of heat occupied a space nearly distinct from that occupied by the primary colours, and upon further examination, the greatest quantity of heat was found to occupy a portion of surface one inch and a half beyond the illuminated spectrum of component rays; but as these experiments made it sufficiently evident, that a very close analogy subsisted between the character of the laws which govern the actions of heat and light, it became particularly desirable to have an accurate

view of some feature in the one or the other sufficiently prominent to mark the distinction, and to guide our conceptions. This has been accomplished by Mr. John Leslie.

The patient research and the mathematical precision, with which he conducted a long and troublesome series of experiments, constituting in the aggregate a system of knowledge of much immediate practical utility, entitle him to a place in the highest rank among the cultivators of this branch of natural philosophy. The principal instrument which he made use of, and to which he was indebted for his most important results, was the Differential Thermometer, for an account of which, with his method of using it, I must beg leave to refer to his book.

As I was extremely desirous to repeat his experiments, and to pursue the subject, I made every exertion to procure a Differential Thermometer, but from the extreme delicacy of the instrument, and the difficulty of uniting the tubes as directed by Mr. Leslie, I could not obtain one, even from the best artists, possessing a sufficient degree of accuracy. My mirrors, made with great precision in Paris, were therefore almost useless. This difficulty was, however, soon removed by a new form of the Differential Thermometer, which I was by a variety of expedients led to adopt; and as it appears to me to possess some advantages superior to that of Mr. Leslie, I have taken the liberty to present one to the Society.

The principal advantage which appears to me to be derived from this form of the Differential Thermometer, is the facility with which it may be made. To render this more evident, it will be necessary to call the attention of the Society to the description of the Differential Thermometer as invented by Mr. Leslie.—" Two glass tubes of unequal lengths, each terminating in a hollow ball, and having their bores somewhat widened at the other ends, a small portion of sulphuric acid tinged with carmine, being introduced into the ball of the longer tube, are joined together by the flame of the blowpipe, and afterwards bent into nearly the shape of the letter U, the one flexure being made just below the joining, where

the small cavity facilitates the adjustment of the instrument; which, by a little dexterity, is performed by forcing with the heat of the hand a few minute globules of air from the one ball into the other. The balls are blown as equal as the eye can judge, and from 4-10ths to 7-10ths of an inch in diamemeter. The tubes are such as are drawn for mercurial thermometers, only with wider bores; that of the short one, and to which the scale is affixed, must have an exact calibre of a fiftieth or sixtieth of an inch; the bore of the long tube need not be so regular, but should be visibly larger as the coloured liquor will then move quicker under any impression. Each leg of the instrument is from three to six inches in height, and the balls are from two to four inches apart. The lower portion of the syphon is cemented at its middle to a slender wooden pillar inserted into a round or square bottom, and such that the balls stand on a level with the centre of the speculum. A moment's attention to the construction of this instrument will satisfy us that it is affected only by the difference of heat in the corresponding balls, and is calculated to measure such differences with peculiar nicety. As long as the balls are of the same temperature, whatever this may be, the air contained in the one will have the same elasticity as that in the other, and consequently the intercluded coloured liquor, being thus pressed equally in opposite directions, must remain stationary. But if, for instance, the ball which holds a portion of the liquor be warmer than the other, the superior elasticity of the confined air will drive it forwards, and make it rise in the opposite branch above the zero, to an elevation proportional to the excess of elasticity or of heat."*

The difficulty of procuring the above instrument arising from the great dexterity necessary in uniting the tubes by the flame of the blow-pipe, and the difficulty of carrying it to a distance in consequence of its shape and delicacy of construction, induced me to endeavour to discover some expedient by which I should be in possession of a thermometer, acting

* Leslie's Inquiry, p. 9.

according to the principles which governed Mr. Leslie's, but more portable and less difficult of acquisition. Having procured, in the summer of 1811, all the apparatus necessary for the experiments upon radiant heat, except the Differential Thermometer of Mr. Leslie, I attempted to make one capable of answering my purpose, by immersing the open termination of a common thermometer tube, blown at the other end into a ball of 7-10ths of an inch in diameter, into concentrated sulphuric acid, tinged with carmine,* contained in an ounce phial; and by luting the mouth of the phial to exclude the external air, and introducing into the tube in the usual way a little of the acid, I had an instrument which appeared capable of assisting my observations; but I soon perceived that it laboured under an imperfection incompatible with the accuracy required in a series of experiments so delicate as those in which I was engaged. I remarked that when I removed the instrument from a room of a given temperature to a room the temperature of which was higher, a sudden depression of the fluid occurred, although after a few minutes had elapsed, it resumed its former position, and when the instrument during an experiment was placed with the ball in the focus of one of the mirrors, a depression of the fluid occurred to a greater degree than the quantity of radiant heat in the focus would have produced. It also appeared frequently to have lost in a great measure its sensibility; or the fluid was not depressed to the degree which from previous observation I was convinced it should have been. I at length found that these irregularities were connected with accidental changes in the atmospheric temperature, by which the air in the ball was sooner affected, from the extreme thinness of the glass, than the air contained in the phial, the glass of which was comparatively very thick.

The imperfect conducting power of glass with relation to heat, by free communication, and the proof given by Mr.

* The ordinary thermometrical fluids will not answer the purpose. Spirit of wine is *totally inadmissible*.—Leslie on Heat, p. 410.

Leslie, in his Seventh Experiment, p. 30, that its character is similar with relation to radiating heat, rendered the method of removing the imperfection of my instrument sufficiently obvious. It was only necessary to equalise the opposition made to the passage of heat to and from the upper and lower portions of included air, and as it would improve the beauty of the instrument, and increase the facility of inclosing it in a tube or case, I determined to have the quantities of air above and below as nearly as possible, equal. I therefore procured a glass tube closed at one end, in the middle of which I caused a ball to be blown almost as thin as the common thermometer-ball. Into this, concentrated sulphuric acid tinged with carmine, was poured, until the fluid stood at the point C. (Plate IX. fig. 1.) A thermometric tube with a ball also blown very thin, and an inch in diameter, open at its other end, was introduced into the glass containing the acid, until its open termination had passed about 1-10th of an inch below the surface of the acid on the point *b*. The stem of the thermometer was made sufficiently large to be embraced closely by all that portion of the lower glass above the ball. The instrument was placed upon its stand, as in the figure, and white lead in oil was laid on with a camel-hair pencil in repeated coats, at the point *a*, until there was no longer any connexion between the external and inclosed air. When the cement was perfectly dry, the upper ball was heated as usual, by which a small portion of air was thrown into the lower ball, and upon removing the heating cause, the acid of course rose to the required height in the tube. The scale was adapted to it by first marking the distance of the part of the tube at which the fluid stood, from the part at which the glasses were cemented; then, determining the temperature of the atmosphere by a common thermometer, the lower ball of the instrument was plunged into water ascertained to be 10° of Fahrenheit colder. This produced a determinate depression of the fluid in the tube, which in this thermometer happened to be exactly at the point of junction. The space between the above two points was divided into 100

parts or degrees, 10 degrees upon this scale indicating of course one degree of Fahrenheit. The instrument was then ready for use, and I had the gratification of finding it free from any imperfection calculated to mislead during the progress of experimental observation.

The capability which it possesses of being applied to fluids, when we wish to detect very minute variations of temperature, is in many cases of considerable importance, as for example, in certain chemical combinations, in which the quantity of heat evolved upon mixing fluids, cannot be appreciated by the common thermometer.

In experimenting upon that part of the subject of radiant heat, which by a strange confusion of ideas has been termed radiating cold, by placing the lower ball of the instrument in the focus of the mirror, the quantity of heat lost by radiation will be indicated by the depression of the coloured acid.

To those persons who have considered attentively, the Photometrical experiments of Mr. Leslie, the easy application of this instrument to a similar purpose will be evident, by making the upper ball of black glass, or by adapting a metallic ball to the top of the tube, and it may perhaps be considered as a more convenient form than Mr. Leslie's, from the facility of inclosing it in a glass tube or case, which is essential to an accurate Photometrical result.*

Having made use of the instrument presented to the society now more than three years, and finding that during that time, it was honoured with the approbation of my scientific friends to whom I had an opportunity of showing it, I have taken the liberty of presenting to the society the above short description of it.

ELISHA DE BUTTS.

* Leslie's Inquiry into the Nature of Heat, p. 423.

Fig. 1.

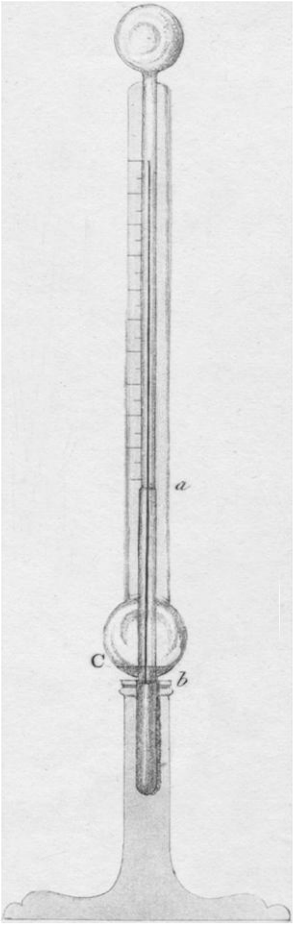

Fig. 2.

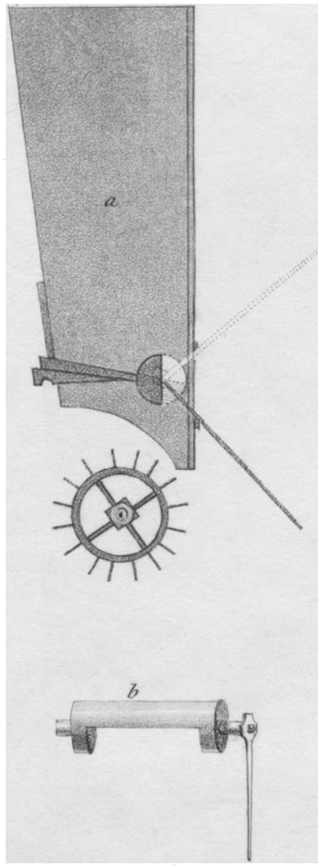

Fig. 3.

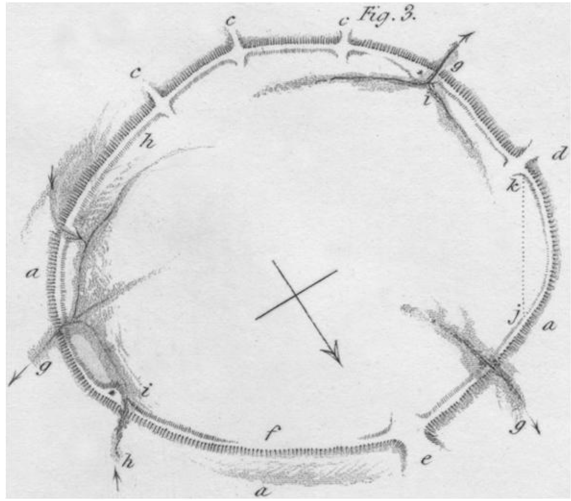

Fig. 4.

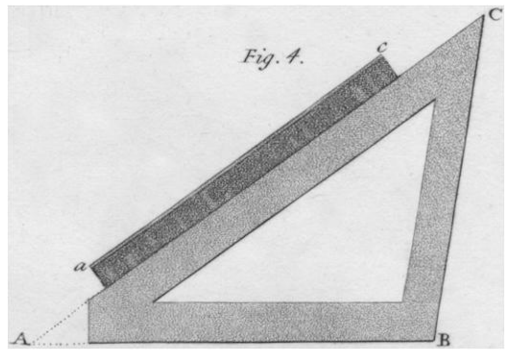

Fig. 6.

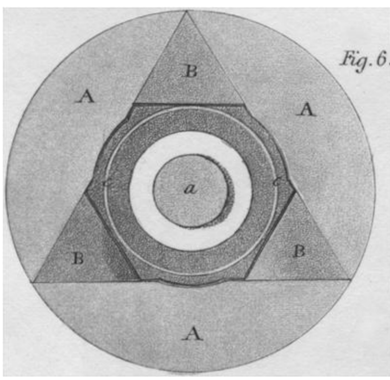

Fig. 5.

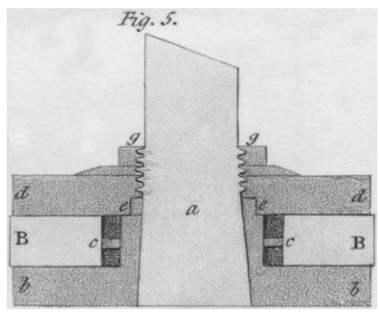

Fig. 8.

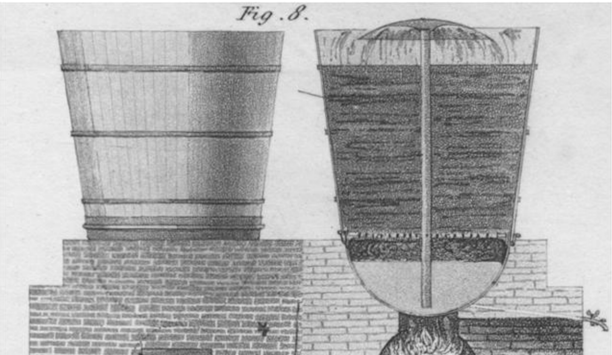

Fig. 9.

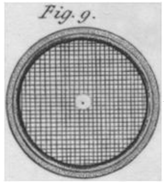

Fig. 7.

Eng.d by J. Hill.